On the Amount and Character of Organic Matter in Soils,

AND

Its Bearing on the Storage of Water in Reservoirs.

By THOMAS M. DROWN, M.D., Chemist of the Board.

Reprinted from the 25th Annual Report of the Massachusetts State Board of Health for 1893.

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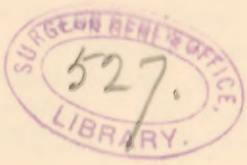

ON THE AMOUNT AND CHARACTER OF ORGANIC MATTER IN SOILS AND ITS BEARING ON THE STORAGE OF WATER IN RESERVOIRS.*

By Thomas M. Drown, M.D., Chemist of the Board.

Many statements have been made in previous reports of the Board, concerning the injurious effect on impounded water of the organic matter in the bottoms and sides of reservoirs, and great stress has been laid on the importance of removing all vegetation, as well as the upper layers of the soil, before filling a new basin with water.†

In order to determine in any case just how far it is necessary to go in the removal of the surface soil, a knowledge of the composition of the soil, based on chemical analysis, is a much surer guide than the unaided eye. It is not merely a question of the effective cleaning of the bottom and sides of the reservoir, but also of avoiding the expense involved in stripping the soil to a greater depth than is necessary. In connection with the investigations of the State Board of Health, relative to a water supply for the city of Boston and its suburbs, surveys have been made for an immense storage reservoir on the south branch of the Nashua River above Clinton, and it was thought desirable that a thorough knowledge of the character of the soil should be obtained as a basis for determining the amount which it would be necessary to remove to obtain a clean bottom and sides practically free from organic matter. Samples of soils, representing sections of the ground to a depth of three feet, were taken at nine places in Clinton, Sterling, West Boylston, and Boylston, and in one case at the bottom of a mill pond.

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* Reprinted from the 25th annual report of the Mass. State Board of Health for 1893.

† Compare special report of the State Board of Health upon the Examination of Water Supplies, 1890, pages 748, 772, 773; annual report of State Board of Health for 1891, page 381.

Each of these nine sections were divided into six or seven samples for analysis, the upper portion being divided into thin layers of two to three inches, the lower portions, with less organic matter, into layers of six inches to one foot in depth.

The amount of organic matter in these samples was determined (after careful drying to a constant weight at 100° C.) by heating the samples to a bright red heat. The loss on ignition thus obtained represents approximately the organic matter in the samples. But in order to get a better knowledge of the character of this organic matter, the amounts of carbon and of nitrogen were also determined in each sample,— the former by combustion in oxygen, the latter by the Kjeldahl method. In series 9 and 10, the amount of hydrogen was also determined.*

Owing to the heterogeneous character of many of the samples, composed often of a mixture of soil, roots and large stones, it is sometimes extremely difficult to get a sample for analysis that shall fairly represent the layer in question. Perhaps some of the apparent irregularities in the results may be due to this cause. But though this difficulty is inherent in the investigation, it is not believed to seriously affect the results, or the conclusions drawn from them.

The results obtained in the analyses of the nine sections of soil, and the deposit from the bottom of the mill pond, are given in the accompanying tables. The largest amount of organic matter found was from a swamp at the head of Boylston Mill Pond (Series 7), and the next largest in amount from the hillside near the site of the proposed dam (Series 4). The other series, from very dissimilar ground, did not differ very widely in the amount of organic matter present, although they included both unwooded and uncultivated land and wooded and manured pasture land. But in all the series there is usually a rapid falling off in the amount of the organic matter below a depth of nine to eleven inches. At the depth of three feet the amount of organic matter, as shown by the loss on ignition, in no case reaches two per cent., and in the majority of the cases it is below one per cent. The mud taken from the bottom of the Mill Pond at different points contained very variable amounts of organic matter, from almost nothing at one place in the shallow portion to nearly 15 per cent. in the deeper portion.

It was thought that the relation of the amount of nitrogen to the amount of carbon in the organic matter might throw some light on its character and its likelihood to undergo decomposition. This relation is given to the column headed $\frac{C}{N}$. The only series in which the nitrogen ratio is noticeably higher than the rest is No. 5, from low pasture land. Series Nos. 4 and 6, both from hillsides, show a noticeably high carbon ratio, and the others are not very dissimilar in their proportion of carbon to nitrogen.

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* All the analyses in this investigation were made by Miss Elizabeth Mason.

An attempt was made to imitate the conditions which would obtain if the reservoir should be filled with water without removing the soil, in order to determine what would be the effect of each of the soils examined on water in contact with it. It is obvious that no laboratory experiment could exactly reproduce the conditions which would exist in a reservoir. Thus it would not be easy to imitate the period of long stagnation of the water during the summer, when the deeper layers of the water are in contact with the soil without an opportunity to get a fresh supply of oxygen from the air. Still it was thought that some idea of the effect of the different soils on the water could be obtained by treating the samples with water for a definite time, and then examining the solutions thus obtained with respect to the character of the organic matter dissolved. In order to hasten the action of the water on the soils, it was heated to 65° C., and the time of contact at this temperature was six hours. The waters were then filtered and the filtrate examined by the usual methods used in the sanitary analysis of water. After standing one week the waters were again tested for free ammonia, to ascertain the amount of decomposition which had gone on in this time, thus obtaining information as to the character of the organic matter dissolved. The *actual amounts* of organic matter found in these solutions, as indicated by the albuminoid ammonia and oxygen consumed, are not especially significant, since they would probably have been very different if another temperature or a greater or less time of treatment had been adopted. But a comparison of the amounts dissolved from the soils in each series, and a comparison of the series with each other, yield information as to the relative facility with which each of the samples examined gives up organic matter to water with which it comes in contact.

In the various experiments tried the proportion of soil to water differed, and in some cases distilled water was used and in others Cochituate water. But in the tables the results of series 1 to 8 have been calculated to represent the effect of the treatment of 100 grams of soil with two litres of pure water at 65° C. for six hours. In series 9 and 10 no heat was employed. In these experiments 250 grams of each sample were placed in a bottle with two litres of pure distilled water. After one week, one litre of this water was filtered off and analyzed, and at the end of the second week the remaining water was examined.

In comparing these tables of analyses of the waters with the corresponding tables giving the percentage determinations of loss on ignition, carbon and nitrogen, a general agreement will be noticed; that is to say, the samples containing the most organic matter give, as a rule, the most concentrated solutions of organic matter. But the analyses do not indicate more than a very general correspondence of this kind. It will also be noted that the amount of decomposition going on in these solutions, indicated by the increase of free ammonia on standing one week, is, in general, also

proportional to the amount of organic matter present. The most notable increase in the free ammonia is generally in the solutions prepared from the surface samples. In solutions from the deeper samples there is generally a decrease of free ammonia indicating doubtless its oxidation to nitrates. The samples from the bottom of the Mill Pond (series 8) give solutions which have little or no tendency to develop free ammonia. This might be expected from the fact that the organic matter they contain has long been in contact with water.

The effect of the soil on the color of water is given both for colorless distilled water, and for Cochituate water having an original color of about 0.55 on the scale used in the analyses of the State Board of Health. In these color determinations the water was not heated, and the length of time of contact with the soil was about 18 hours. It will be noticed that in some cases the deeper samples actually diminished the color of the Cochituate water.

As a preliminary conclusion, based on the facts determined in this investigation, it may be said that the effect of the organic matter in these various soils on the water in contact with them is simply a question of its amount, and that its origin and composition seem to be without marked influence. The watershed from which the samples were taken is very sparsely populated, and the organic matter in all cases is mainly of vegetable origin.

It is probable, therefore, that we need only concern ourselves with the amount of organic matter in a soil of this character in determining the necessity of its removal, and as a provisional standard we may perhaps fix 1.5 to 2 per cent. of organic matter, as determined by the loss on ignition of the sample dried at 100° C., as the permissible limit of organic matter that may be allowed to remain on the bottom and sides of a reservoir.

Series 1.

From a Cornfield One-quarter Mile below Clarendon Mills, West Boylston. Cultivated Fertilized Ground in Bottoms. Samples taken from Surface to Three Feet below Surface. All Samples dried at 100° C.

	Loss on Ignition. (Per Cent.)	Carbon. (Per Cent.)	Nitrogen. (Per Cent.)	Ratio. $\frac{c}{n}$
1*a*. Surface to 2 in. below,	8.54	5.12	0.47	10.9
1*b*. 2 in. to 4 in. below surface,	6.83	3.55	0.21	16.9
1c. 4 in. to 6 in. below surface,	7.43	3.47	0.30	11.5
1*d*. 6 in. to 9 in. below surface,	4.27	2.03	0.21	9.7
1*e*. 9 in. to 14 in. below surface,	1.37	0.26	0.04	6.5
1*f*. 14 in. to 20 in. below surface,	1.07	0.16	0.02	8.0
1*g*. 3 feet below surface,	0.78	0.15	0.05	3.0

Sanitary Analysis of Water with which the Soils had been treated as described.

[Parts per 100,000.]

	Free Ammonia.	Free Ammonia after Standing One Week.	Albuminoid Ammonia.	Oxygen Consumed.	Color with Distilled Water.	Effect of Soils on Color of Cochituate Water of Color 0.55.
1*a*. Surface to 2 in. below,	0.0343	0.1107	0.1914	2.2368	Not det'd.	Not det'd.
1*b*. 2 in. to 4 in. below surface,	0.0424	0.0984	0.1437	2.0837	"	"
1c. 4 in. to 6 in. below surface,	0.0317	0.0913	0.1538	2.5290	"	"
1*d*. 6 in. to 9 in. below surface,	0.0317	0.0359	0.0881	0.9733	"	"
1*e*. 9 in. to 14 in. below surface,	0.0212	0.0076	0.0351	0.4947	"	"
1*f*. 14 in. to 20 in. below surface,	0.0194	0.0076	0.0189	0.2515	"	"
1*g*. 3 feet below surface,	0.0229	0.0374	0.0105	0.2763	"	"

Series 2.

From a very Steep Slope One-quarter Mile below Clarendon Mills, West Boylston. Not wooded or cultivated. Samples taken from Surface to Three Feet below Surface. All Samples dried at 100° C.

	Loss on Ignition. (Per Cent.)	Carbon. (Per Cent.)	Nitrogen. (Per Cent.)	Ratio. $\frac{c}{n}$
2*a*. Surface to 2 in. below,	4.55	2.26	0.14	16.1
2*b*. 2 in. to 4 in. below surface,	10.19	5.00	0.27	18.5
2*c*. 4 in. to 7 in. below surface,	7.62	2.52	0.36	7.0
2*d*. 7 in. to 10 in. below surface,	7.70	2.93	0.21	14.0
2*e*. 10 in. to 16 in. below surface,	1.01	0.18	0.05	3.6
2*f*. 16 in. to 22 in. below surface,	1.63	0.24	0.13	1.8
2*g*. 3 feet below surface,	0.80	0.23	0.03	7.7

Sanitary analysis of water with which the Soils had been treated as described.

[Parts per 100,000.]

	Free Ammonia.	Free Ammonia after Standing One Week.	Albuminoid Ammonia.	Oxygen Consumed.	Color with Distilled Water.	Effect of Soils on Color of Cochituate Water of Color 0.55.
2*a*. Surface to 2 in. below,	0.0340	0.0669	0.0852	1.4732	0.40	0.90
2*b*. 2 in. to 4 in. below surface,	0.0227	0.1215	0.1372	2.3334	0.48	1.00
2*c*. 4 in. to 7 in. below surface,	0.0227	0.0335	0.1261	2.3092	0.35	0.85
2*d*. 7 in. to 10 in. below surface,	0.0178	0.0062	0.1349	2.6945	0.52	0.85
2*e*. 10 in. to 16 in. below surface,	0.0307	0.0130	0.0205	0.5428	0.15	0.70
2*f*. 16 in. to 22 in. below surface,	0.0190	0.0000	0.0196	0.4560	–	–
2*g*. 3 feet below surface,	0.0323	0.0213	0.0267	0.3756	0.00	0.45

Series 3.

From Pasture Land One Mile North of South Clinton Station. Sandy and Gravelly and Nearly Level. Samples taken from Surface to Three Feet below Surface. All Samples dried at 100° C.

	Loss on Ignition. (Per Cent.)	Carbon. (Per Cent.)	Nitrogen. (Per Cent.)	Ratio. $\frac{c}{n}$
3a. Surface to 2 in. below,	7.85	3.51	0.27	13.0
3b. 2 in. to 4 in. below surface,	5.85	2.18	0.24	9.1
3c. 4 in. to 6 in. below surface,	4.93	2.28	0.20	11.4
3d. 6 in. to 11 in. below surface,	1.73	0.50	0.03	16.7
3e. 11 in. to 16 in. below surface,	1.43	0.13	0.04	3.3
3f. 16 in. to 36 in. below surface,	0.81	0.02	0.02	1.0

Sanitary Analysis of Water with which the Soils had been treated as described.

[Parts per 100,000.]

	Free Ammonia.	Free Ammonia after Standing One Week.	Albuminoid Ammonia.	Oxygen Consumed.	Color with Distilled Water.	Effect of Soils on Color of Cochituate Water of Color 0.55.
3a. Surface to 2 in. below,	0.0341	0.0541	0.1540	1.4423	0.30	0.60
3b. 2 to 4 in. below surface,	0.0457	0.0693	0.1041	1.4855	0.22	0.65
3c. 4 in. to 6 in. below surface,	0.0857	0.0745	0.0888	1.2000	0.15	0.60
3d. 6 in. to 11 in. below surface,	0.0427	0.0138	0.0321	0.4361	0.12	0.50
3e. 11 in. to 16 in. below surface,	0.0400	0.0200	0.0125	0.1689	0.00	0.18
3f. 16 in to 36 in. below surface,	0.0214	0.0121	0.0067	0.1000	0.00	0.33

Series 4.

From a very Steep, Clayey Hillside near Site of Proposed Dam. Samples taken from Surface to 3 feet below surface. All Samples dried at 100° C.

	Loss on Ignition. (Per Cent.)	Carbon. (Per Cent.)	Nitrogen. (Per Cent.)	Ratio. $\frac{c}{n}$
4*a*. Surface to 2 in. below, ...	17.79	8.19	0.56	14.6
4*b*. 2 in. to 4 in. below surface, . . .	11.04	5.85	0.38	15.4
4*c*. 4 in. to 6 in. below surface, . . .	8.55	4.31	0.12	35.9
4*d*. 6 in. to 11 in. below surface, . . .	4.04	1.26	0.05	25.2
4*e*. 11 in. to 16 in. below surface, . . .	2.80	0.47	0.03	15.7
4*f*. 3 feet below surface, ...	1.76	0.10	0.01	10.0

Sanitary Analysis of Water with which the Soils had been treated as described.

[Parts per 100,000].

	Free Ammonia.	Free Ammonia after Standing One Week.	Albuminoid Ammonia.	Oxygen Consumed.	Color with Distilled Water.	Effect of Soils on Color of Cochituate Water of Color 0.55.
4*a*. Surface to 2 in. below, . .	0.0622	0.3555	0 4240	7.7333	0.30	0.75
4*b*. 2 in. to 4 in. below surface, .	0.2581	0.4749	0.8032	8.0323	0.30	0.75
4*c*. 4 in. to 6 in. below surface, .	0.0454	0.1513	0.1968	4.2622	0.48	0.80
4*d*. 6 in. to 11 in. below sutface, .	0.0071	0.0267	0.0542	1.0422	0.32	0.55
4*e*. 11 in. to 16 in. below surface, .	0.0077	0.0154	0.0369	0.5427	0.12	0.55
4*f*. 3 feet below surface, . . .	0.0138	0.0092	0.0155	0.3000	0.40	0.70

Series 5.

From Level Pasture Land near River, Half a Mile East of Boylston Station. Silt Formation. Samples taken from Surface to Three Feet Six Inches below Surface. All Samples dried at 100° C.

	Loss on Ignition. (Per Cent.)	Carbon. (Per Cent.)	Nitrogen. (Per Cent.)	Ratio. $\frac{c}{n}$
5a. Surface to 2 in. below,	9.40	4.19	0.43	9.7
5b. 2 in. to 4 in. below surface,	3.94	1.33	0.15	8.9
5c. 4 in. to 7 in. below surface,	3.04	1.02	0.11	9.3
5d. 7 in. to 10 in. below surface,	2.12	0.63	0.10	6.3
5e. 10 in. to 15 in. below surface,	2.51	0.73	0.09	8.1
5f. 15 in. to 20 in. below surface,	0.88	0.16	0.03	5.3
5g. 3 ft. 6 in. below surface,	1.09	0.21	0.02	10.5

Sanitary Analysis of Water with which the Soils had been treated as described.

[Parts per 100,000.]

	Free Ammonia.	Free Ammonia after Standing One Week.	Albuminoid Ammonia.	Oxygen Consumed.	Color with Distilled Water.	Effect of Soils on Color of Cochituate Water of Color 0.55.
5a. Surface to 2 in. below,	0.0349	0.2573	0.5556	2.7619	0.20	0.70
5b. 2 in. to 4 in. below surface,	0.0533	0.0195	0.0636	1.5876	0.20	0.65
5c. 4 in. to 7 in. below surface,	0.0380	0.0099	0.0670	0.8444	0.20	0.70
5d. 7 in. to 10 in. below surface,	0.0166	0.0325	0.0316	0.2882	0.20	0.60
5e. 10 in. to 15 in. below surface,	0.0182	0.0117	0.0519	0.6127	0.25	0.70
5f. 15 in. to 20 in. below surface,	0.0188	0.0041	0.0199	0.2726	0.00	0.45
5g. 3 ft. 6 in. below surface,	0.0295	0.0533	0.0116	0.2036	0.05	0.50

Series 6.

From Three-quarters of a Mile West of Boylston Centre on Wooded Hillside East of Muddy Brook. Samples taken from Surface to Three Feet below Surface. All Samples dried at 100° C.

	Loss on Ignition. (Per Cent.)	Carbon. (Per Cent.)	Nitrogen. (Per Cent.)	Ratio. $\frac{c}{n}$
6*a*. Surface to 2 in. below,	9.69	8.93	0.11	81.2
6*b*. 2 in. to 4 in. below surface,	4.31	1.30	0.04	32.5
6*c*. 4 in. to 7 in. below surface,	4.06	0.91	0.11	8.3
6*d*. 7 in. to 10 in. below surface,	2.83	0.69	0.02	34.5
6*e*. 10 in. to 16 in. below surface,	2.50	0.30	0.02	15.0
6*f*. 3 ft. below surface,	1.77	0.16	0.01	16.0

Sanitary Analysis of Water with which the Soils had been treated as described.

[Parts per 100,000.]

	Free Ammonia.	Free Ammonia after Standing One Week.	Albuminoid Ammonia.	Oxygen Consumed.	Color with Distilled Water.	Effect of Soils on Color of Cochituate Water of Color 0.55.
6*a*. Surface to 2 in. below,	0.0800	0.2921	0.4726	7.0009	0.60	1.00
6*b*. 2 in. to 4 in. below surface,	0.0392	0.0574	0.0770	1.5740	0.30	0.70
6*c*. 4 in. to 7 in. below surface,	0.0361	0.0323	0.0519	1.0977	0.38	0.60
6*d*. 7 in to 10 in. below surface,	0.0209	0.0116	0.0243	0.3368	0.10	0.53
6*e*. 10 in to 16 in. below surface,	0.0340	0.0142	0.0288	0.5060	0.20	0.55
6*f*. 3 ft. below surface,	0.0142	0.0077	0.0110	0.1478	0.00	0.10

Series 7.

From Swamp at Head of Boylston Millpond, about Three-quarters of a Mile above Boylston Station. Samples taken from Surface to Three Feet Three Inches below Surface. All Samples dried at 100° C.

	Loss on Ignition. (Per Cent.)	Carbon. (Per Cent.)	Nitrogen. (Per Cent.)	Ratio. $\frac{c}{n}$
7a. Surface to 2 in. below,	22.31	12.53	0.96	13.0
7b. 2 in. to 4 in. below surface,	24.59	13.05	0.54	24.2
7c. 4 in. to 8 in. below surface,	17.12	8.75	0.86	10.2
7d. 8 in. to 12 in. below surface,	9.14	3.96	0.21	18.9
7e. 12 in. to 21 in. below surface,	3.93	1.44	0.09	16.0
7f. 21 in. to 39 in. below surface,	1.98	0.51	0.04	12.8
7g. 39 in. below surface,	0.66	0.06	0.00	-

Sanitary Analysis of Water with which the Soils had been treated as described.

[Parts per 100,000.]

	Free Ammonia.	Free Ammonia after Standing One Week.	Albuminoid Ammonia.	Oxygen Consumed.	Color with Distilled Water.	Effect of Soils on Color of Cochituate Water of Color 0.55.
7a. Surface to 2 in. below,	0.1360	0.4000	0.4970	6.4000	0.40	0.70
7b. 2 in. to 4 in. below surface,	0.1486	0.5429	0.4486	7.4286	0.50	0.90
7c. 4 in. to 8 in. below surface,	0.1360	0.3440	0.4970	4.6000	0.12	0.55
7d. 8 in. to 12 in. below surface,	0.0274	0.0709	0.0937	2.7429	0.50	1.00
7e. 12 in. to 21 in. below surface,	0.0305	0.0267	0.0438	1.0857	0.30	0.70
7f. 21 in. to 39 in. below surface,	0.0173	0.0229	0.0502	0.8471	0.10	0.55
7g. 39 in. below surface,	0.0179	0.0245	0.0080	0.1365	0.02	0.45

Series 8.

From Bottom of Oakdale Millpond from Depths of Three to Twelve Feet. All Samples dried at 100° C.

	Loss on Ignition. (Per Cent.)	Carbon. (Per Cent.)	Nitrogen. (Per Cent.)	Ratio. $\frac{c}{n}$
8*a*. Near head in 3 ft. of water, ...	0.91	0.07	0.01	7.0
8*b*. ¼ mile below head in 5 ft. of water, . . .	0.11	0.06	0.00	–
8*c*. ½ mile below head in 7 ft. of water, . . .	10.16	4.10	0.36	11.4
8*d*. ¾ mile from head in 9 feet of water, . . .	10.45	4.17	0.35	11.9
8*e*. 500 ft. above W. & N. R.R. in 12 ft of water, .	14.75	6.56	0.53	12.4
8*f*. 500 ft. below W. & N. R.R. in 12 ft. of water, .	4.72	2.18	0.15	14.5

Sanitary Analysis of Water with which the Soils had been treated as described.

[Parts per 100,000.]

	Free Ammonia.	Free Ammonia after Standing One Week.	Albuminoid Ammonia.	Oxygen Consumed.	Color with Distilled Water.	Effect of Soils on Color of Cochituate Water of Color 0.55.
8*a*. Near head in 3 ft. of water, .	0.0186	0.0121	0.0251	0.2224	0.01	0.55
8*b*. ¼ mile below head in 5 ft. of water.	0.0162	0.0027	0.0144	0.1854	0.00	0.60
8*c*. ½ mile below head in 7 ft. of water.	0.2100	0.2000	0.2042	3.1408	0.50	0.90
8*d*. ¾ mile from head in 9 ft. of water.	0.1707	0.2240	0.2227	3.8500	0.50	0.70
8*e*. 500 ft. above W. & N. R.R. in 12 ft. of water.	0.1943	0.2286	0.1838	2.7500	0.30	0.75
8*f*. 500 ft. below W. & N. R.R. in 12 ft. of water.	0.1103	0.0855	0.0790	1.3707	0.55	0.85

Series 9.

From Pasture Land about One and One-quarter Miles below West Boylston, on South Side of Railroad, which had never been cultivated. Samples taken from Surface to Twenty Inches below Surface. Samples dried at 100° C.

	Moisture. (Per Cent.)	Loss on Ignition. (Per Cent.)	Hydrogen. (Per Cent.)	Carbon. (Per Cent.)	Nitrogen. (Per Cent.)	Ratio. $\frac{c}{n}$
9*a*. Surface to 2 in. below, . .	31.13	19.89	1.45	11.92	0.66	18.06
9*b*. 2 in. to 4 in. below, . . .	29.17	11.52	0.66	5.32	0.48	11.08
9c. 4 in. to 7 in. below, . . .	26.17	8.37	0.62	3.56	0.26	13.69
9*d*. 7 in. to 10 in. below, . .	26.19	5.16	0.42	1.38	0.03	46.00
9*e*. 10 in. to 15 in. below, . .	22.55	3.16	0.31	0.87	0.06	14.50
9*f*. 15 in. to 20 in. below, . .	18.47	2.43	0.22	0.85	0.08	10.63

Sanitary Analysis of Water with which the Soils had been treated as described.

[Parts per 100,000.]

	Free Ammonia.		Albuminoid Ammonia.		Oxygen Consumed.		Color.	
	After 3 Days.	After 1 Week.	After 3 Days.	After 1 Week.	After 3 Days.	After 1 Week.	After 3 Days.	After 1 Week.
9*a*, . . .	0.0096	0.0024	0.0530	0.1436	1.8330	2.1840	1.15	1.50
9*b*, . . .	0.0056	0.0008	0.0254	0.0228	0.3003	0.4368	0.15	0.25
9c, . . .	0.0040	0.0072	0.0188	0.0180	0.1170	0.1326	0.04	0.10
9*d*, . . .	0.0016	0.0048	0.0066	0.0078	0.0429	0.0702	0.00	0.00
9*e*, . . .	0.0096	0.0104	0.0066	0.0072	0,0156	0.0585	0.00	0.00
9*f*, . . .	0.0048	0.0016	0.0050	0.0052	0.0195	0.0624	0.00	0.00

Series 10.

From Land recently cleared of Good-sized Timber and never cultivated, about Midway between Boylston and South Clinton, South Side of Valley. Samples taken from Surface to Two Feet Six Inches below. Dried at 100° C.

	Moisture. (Per Cent.)	Loss on Ignition. (Per Cent.)	Hydrogen. (Per Cent.)	Carbon. (Per Cent.)	Nitrogen. (Per Cent.)	Ratio. $\frac{c}{n}$
10*a*. Surface to 2 in. below, . .	62.87	26.65	1.92	18.07	0.94	19.22
10*b*. 2 in. to 4 in. below, . . .	54.26	19.63	1.15	10.47	0.58	18.02
10*c*. 4 in. to 7 in. below, . . .	44.23	11.12	0.63	5.66	0.32	17.69
10*d*. 7 in. to 12 in. below, . .	32.21	3.40	0.34	1.54	0.20	7.70
10*e*. 12 in. to 17 in. below, . .	29.57	2.85	0.28	0.85	0.31	2.74
10*f*. 2 ft. 6 in. below, . . .	17.60	0.52	0.05	0.04	0.11	0.36

Sanitary Analysis of Water with which the Soils had been treated as described.

[Parts per 100,000.]

	Free Ammonia.		Albuminoid Ammonia.		Oxygen Consumed.		Color.	
	After 3 Days.	After 1 Week.	After 3 Days.	After 1 Week.	After 3 Days.	After 1 Week.	After 3 Days.	After 1 Week.
10*a*, . . .	0.0560	0.0384	0.0902	0.1420	4.0560	6.3180	–	7.50
10*b*, . . .	0.0232	0.0224	0.0382	0.0320	0.8970	1.0257	0.80	4.50
10*c*, . . .	0.0064	0.0032	0.0264	0.0208	0.5144	0.6512	0.80	1.00
10*d*, . . .	0.0056	0.0024	0.0240	0.0254	0.2440	0.6448	0.30	1.20
10*e*, . . .	0.0056	0.0072	0.0738	0.0436	0.1584	1.3280	0.08	1.00
10*f*, . . .	0.0096	0.0024	0.0074	0.0066	0.0864	0.1008	0.03	0.12